Milford Lake Water Quality Summary

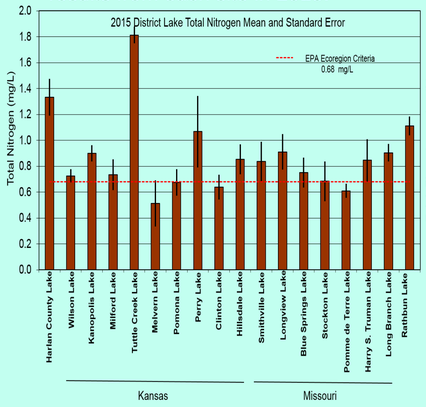
2006-2015

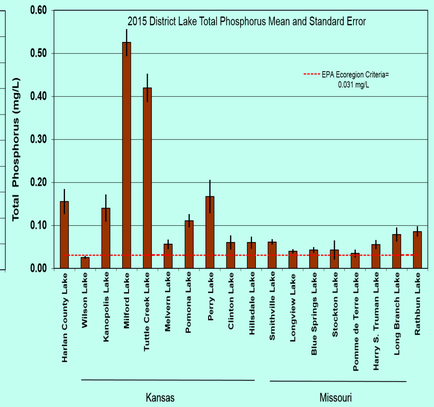
Milford Lake

- Built on Republican River reaching full pool in 1967.
- **Watershed** = 17,388 square miles / 11,130,000 Surface Acres (SA)
- **Capacity**:
  - Flood Control: 756,669 Acre-feet (AF) / 32,979 SA
  - Multipurpose: 388,816 AF / 15,709 SA / 163 miles of shoreline
  - 10-year avg. annual inflow = 495,974 AF; 2015 inflow = 580,858 AF
- **Operating project purposes**: Flood control, water supply, water quality, navigation, recreation, and fish and wildlife conservation.
- **Water Quality** at Milford Lake in 2015 was impacted by harmful algal blooms which required 2 week zoned lake closures and 12 weeks of public health warnings.

Nutrient Enrichment

Nutrients (i.e. phosphorus and nitrogen) are essential for aquatic life and are the primary factor driving fish and aquatic plant growth rates and lake productivity. Excess nutrients from urban, agricultural or natural sources increases the natural aging or eutrophication process and cause algal blooms, create low dissolved oxygen affecting fish survival, and lead to taste and odor issues in drinking water. Milford Lake experienced sizeable algal bloom events in 2011-2015 leading to significant recreational impacts ranging from health watch to lake closure. High nutrient concentrations and resulting harmful algae blooms have elevated Milford Lake to the 2014 Kansas 303(d) list of impaired waters for eutrophication and low dissolved oxygen. Nine inflow stream(s) sections upstream from Milford Lake are also listed for nutrient related water quality impairments. KDHE and EPA are working with water quality partners, landowners and Milford Lake Watershed Restoration and Protection Strategy (WRAPS) group to improve water quality at Milford Lake. WRAPS directs funding for recommended best management practices for target areas in the watershed to improve inflow water quality to meet long term goals for Milford Lake. In 2015, Milford had the second highest total phosphorus concentrations of all District lakes at the upper lake sites and the dam. Standard error bars in the graph below depicts the variation in sample results from each site in 2015.



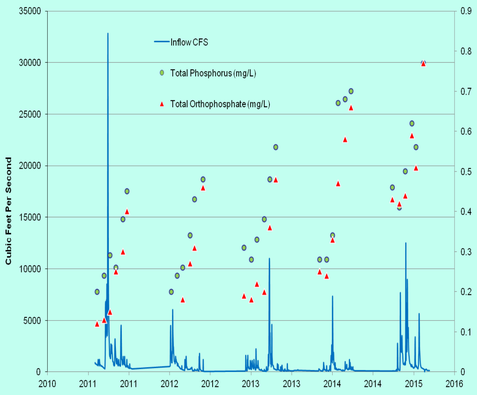


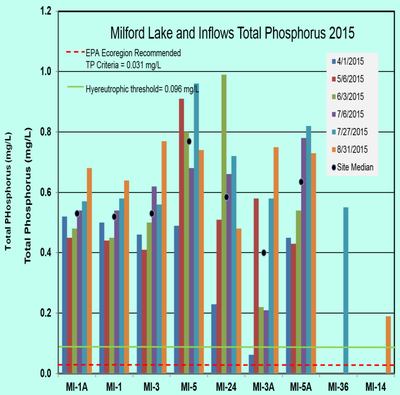
The US Army Corps of Engineers (USACE) Water Quality Program collects monthly water samples at Milford Lake* and inflows from April through September. These figures present data collected between 2006-2015 from three lake sites (#1, 3, 5) and inflows sampled in 2015 (Mi-3a, Mi-5a, and Mi-24) and the outflow (#1A). Thirty-four chemical, physical and biological parameters are measured to evaluate water quality. USACE use this data to describe conditions and changes from the inflows through the lake and outflow focusing on eutrophication, nutrients, sediment, herbicides, metals, and contaminants.

*Note: The term "lake" is substituted for technically correct "reservoir" throughout this document for consistency.

Phosphorus

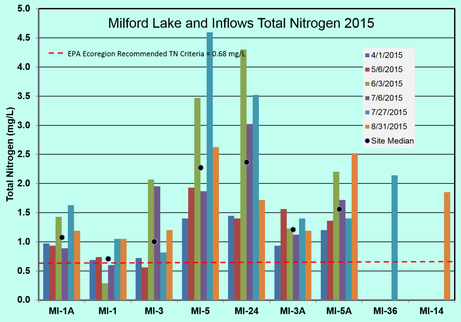
Physical conditions and excessive nutrients in Milford Lake have caused significant toxic blue-green algae blooms in 2011, 2014, and 2015. Total phosphorus medians from all lake sites in 2015 were 5-7 times greater than Carlson's hypereutrophic threshold while all site medians were 12 to 24 times higher than EPA Ecoregion recommended criteria of 0.031 mg/L. High inflows (85% above average) led to a large pulse of phosphorus deposited in Milford Lake. Total phosphorus concentrations were greater in the Republican River at Clay Center (MI-24) than upstream sites at highways 36 (Mi-36) and Highway 14 (Mi-14). Farnum Creek (Mi-3a) and Madison Creek (Mi-5a) had high TP concentrations measured in 2015. Due to low volume of discharge, these two small streams contributed less than 2% of Milford Lake external TP load. Record lake clarity as measured by secchi disk combined with high nutrients to create optimum conditions for blue green algae blooms. Internal sources of phosphorus including orthophosphate re-suspended or released by bottom sediments are apparent as TP and TOP concentrations increase exponentially from June-Sept unrelated to inflow volume or timing in 2011-2014, but corresponded to large inflows in 2015. Wind action, invertebrates, bottom feeding fish and bacteria cause the re-suspension of sediment bound phosphorus.





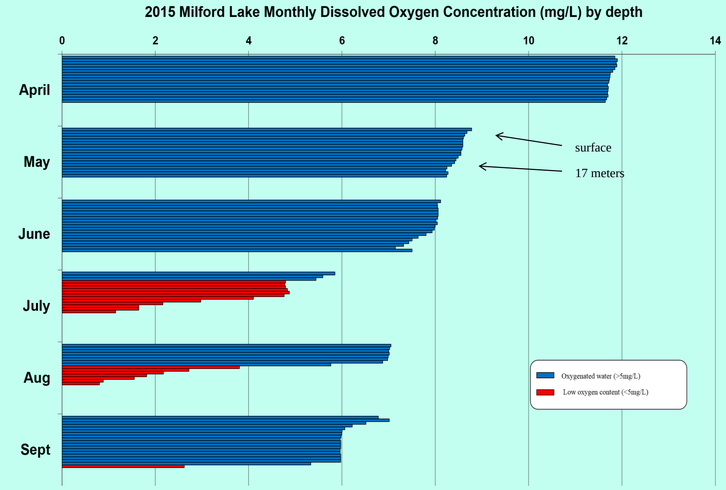
Total Nitrogen

In 2015, total nitrogen concentrations were more variable and slightly reduced compared to the 10-year data range. Only the upper lake site (MI-5) was significantly higher than EPA Ecoregion recommended criteria of 0.68 mg/L. Total nitrogen concentrations are typically variable between sites and years and most related to inflow levels, algae populations, and watershed factors (i.e. soils and farming practices). The available plant nutrient (nitrate) component of the TN calculation is consumed as water moves toward the dam.



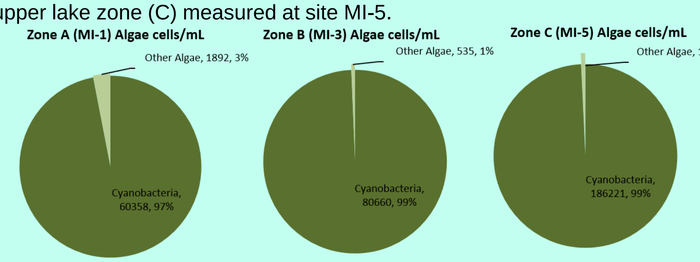
Dissolved Oxygen

Dissolved oxygen is a factor in aquatic species location, growth, and ultimately survival in lakes. The figure below shows dissolved oxygen measured in the water column in one-meter intervals (e.g. each row in each month represents one meter of depth) from April through September. Milford Lake infrequently experiences weak stratification near the dam in summer, however adequate (>5 mg/L) dissolved oxygen exists in the top 3-4 meters of the water column. In 2015, Milford Lake experienced a low D.O period in July in which the top 3 meters was well oxygenated. Increased oxygen consumption from algae decomposition or biological oxygen demand contributes to lower dissolved oxygen after algae blooms, but oxygen related fish kills have not been documented.



Algae

Algae and green plants are the base of the food chain in a lake and function to convert nutrients and CO_2 via photosynthesis into biomass for all aquatic life. Since 2011, late summer algae community in Milford Lake has been dominated by cyanobacteria which out compete beneficial algae. In 2015, 14 weeks of the summer recreation season were impacted by KDHE pubic health advisories for high levels of toxic blue-green algae including 2 weeks of "closure" of the upper lake zone. July sample results below typify lake summer conditions at Milford Lake with maximum cell density and cyanobacteria concentrations found in the upper lake zone (C) measured at site MI-5.



Water Quality Concerns:

- Eutrophication
- Nutrients
- Harmful algae blooms
- Sediment inputs

US Army Corps of Engineers
Environmental Resources Section
Kansas City, MO